Scaling Team Coordination on Graphs with Reinforcement Learning

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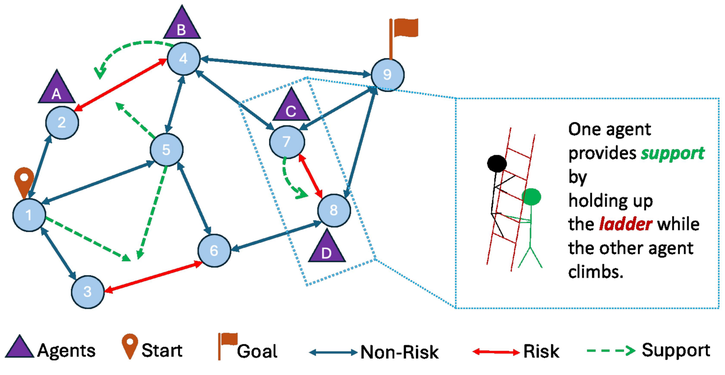
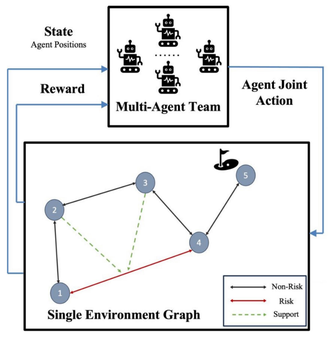
MOTIVATION

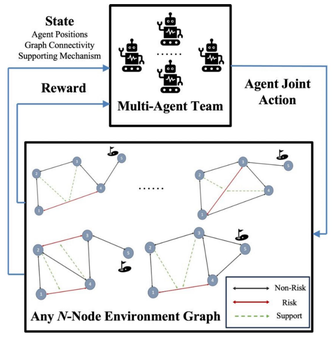


PROBLEM FORMULATION

Formulate it as MDP for Single Environment Graph (Single EG):

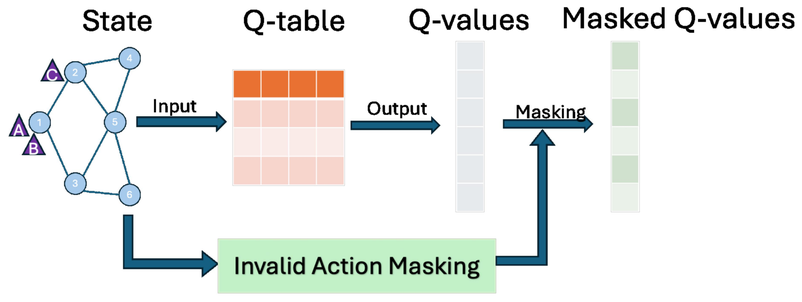


Formulate it as MDP for Multiple Environment Graphs (Multiple EGs):

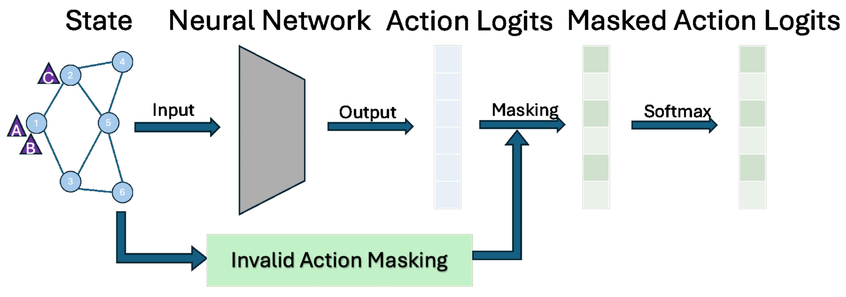


METHODS & IMPLIMENTATIONS

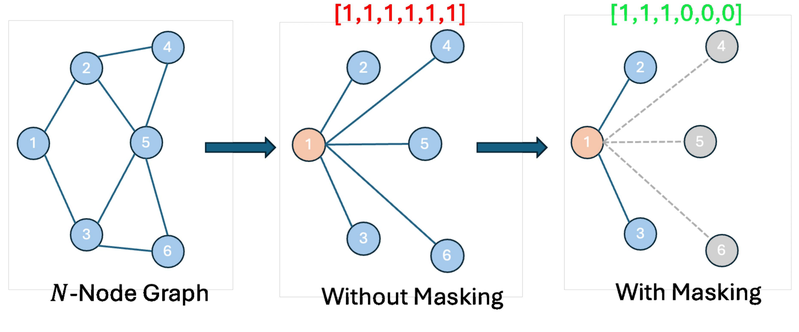
Masked Q-Learning:



Masked PPO:



Invalid Action Masking:



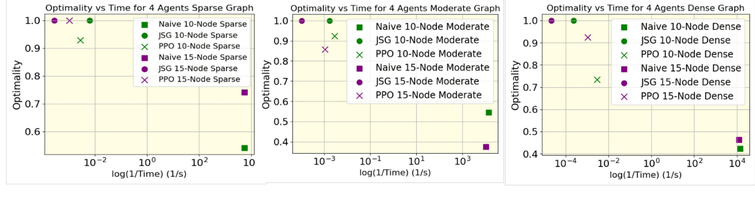
Reward Shaping:

- **Goal Reward:**
  $$r_g = \begin{cases} +10, & if\ all\ agents\ arrive\ at\ at\ goal(s), \\ -0.01, & otherwise \end{cases}$$
- **Movement Reward:**
  $$r_m = -\sum_{n\in\mathbb{N}} = -\sum_{n\in\mathbb{N}} C\left(\{v_t^j, a_t^j\}_{j\in\mathbb{N}}\right)$$
- **Coordination Reward:**
  $$r_c = \alpha \times CC \ - \ \beta \times RC$$
- **Final Reward:**
  $$r_f = w_1\, r_g + w_2\, r_m + w_3\, r_c$$

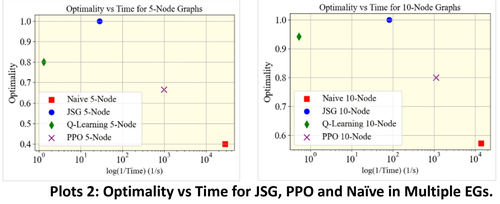
RESULTS:

Graph	Nodes	2 Agents			3 Agents			4 Agents		
		JSG	Q-Learning	PPO	JSG	Q-Learning	PPO	JSG	Q-Learning	PPO
Sparse	5	**0.001**	1.228	58.39	**0.037**	2.863	83.66	**1.093**	9.978	88.74
	10	**0.014**	3.654	81.39	**1.494**	10.35	226.2	157.7	**102.7**	355.8
	15	**0.057**	5.922	201.02	**14.88**	27.88	326.4	3652	–	**962.2**
	20	**0.172**	13.86	560.3	80.16	**45.31**	701.5	–	–	**1045**
	25	**0.394**	–	730.5	**281.0**	–	1432	–	–	–
Moderate	5	**0.002**	0.293	56.97	**0.052**	3.469	74.03	**1.689**	14.34	88.21
	10	**0.022**	2.362	66.17	**3.007**	20.36	146.3	600.5	751.0	**352.2**
	15	**0.088**	2.389	189.6	25.49	**22.79**	317.7	9492	–	**949.4**
	20	**0.277**	3.587	531.0	160.04	**58.26**	683.3	–	–	**1032**
	25	**0.641**	5.720	677.5	571.1	**181.8**	1372	–	–	–
Dense	5	**0.002**	0.874	57.32	**0.072**	1.855	72.44	**0.072**	6.921	89.71
	10	**0.035**	1.963	64.35	**7.927**	15.11	142.3	4312	696.9	**344.8**
	15	**0.109**	6.671	186.4	**39.49**	129.1	317.7	46455	–	**944.1**
	20	**0.433**	2.616	646.2	481.4	**65.22**	677.5	–	–	**1018**
	25	**0.915**	5.192	700.9	1660	7821	**1349**	–	–	–

Table 1: Solution times for 2, 3 and 4 agents using JSG, Q-learning and PPO in single EG



Plots 1: Optimality vs Time for JSG, PPO and Naïve in Single EG.



Plots 2: Optimality vs Time for JSG, PPO and Naïve in Multiple EGs.